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Investigation of Parametric Acoustic Response of a Fluctuating Ocean

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LONG-TERM GOAL

The long-term goals are: 1) to take advantage of the ever-changing ocean environment's effects in order to provide a more complete understanding of long-range acoustic pulse propagation including extracting parameters characterizing the ocean environment, for example, by linking them to range scales of temporal decorrelations in arriving signals, 2) understanding the extent of fundamental limitations on ray-based acoustic tomography; of particular interest is the breakdown range of semiclassical methods, and 3) to address important basic physics issues that arise in the ocean problem, but within a more general context.

OBJECTIVES

There are two primary scientific objectives of this work: 1) to begin developing a geometric acoustics theory that addresses parametrically varying ocean environments in the presence of ray chaos, determines what information survives under such conditions, and determines how to extract it, and 2) to determine the sensitivity of acoustic wavefields to relevant ocean environment parameters thereby connecting the scale of changes in the ocean to range scales of wavefield correlation decay.

APPROACH

We consider acoustic propagation problems that allow for parabolic equation description. Advantage is taken of new semiclassical approaches to approximate time-evolving wavefields in systems possessing classically chaotic analogs. The methods rely on wave packets, heteroclinic orbit summations, and have been shown to be remarkably accurate in spite of relying on highly unstable chaotic trajectories. The approach is similar in spirit to the van Vleck approximate propagator, and the Gutzwiller trace formula. From this starting point, we consider systems whose governing equations can be expressed as varying with respect to a parameter; this can model, for example, a time-changing internal wave configuration. To study response and sensitivity, it is fruitful to apply perturbation theory to describe the changes arising in ensembles of classical trajectories underlying the wavefields. We compare semiclassical predictions with 'exact' numerical wavefield calculations.

WORK COMPLETED

In conjunction with a Washington State University Ph. D. student, Nicholas Cerruti, the principal accomplishments of the last year are: 1) the derivation of theoretical results for the scale of eigenlevel motions based on mean square changes in classical trajectory actions as a function of a perturbation, 2)

extensions of known perturbative expressions for periodic orbit actions to homoclinic orbits, 3) derivations of semiclassical expressions for dynamical correlations between weighted level velocities, 4) new arguments leading to the expectation of the applicability of statistical random matrix model results, and 5) calculations on simple chaotic model systems giving partial verification of the above theory.

IMPACT/APPLICATION

The work is aimed at understanding the predictability and/or other limitations of ray methods in the presence of unstable dynamics. In addition, parametric variation, once understood, is often found to be one of the only successful ways of deducing otherwise difficult-to-ascertain information about complex systems such as the ocean environment.

RELATED PROJECTS

Additional work currently underway, but not fully described in this report, involves extensive collaborations with the following individuals: M. Wolfson (WSU) and M. Brown (RSMAS-AMP).

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